PRE-OPERATIONAL AIR AND WATER QUALITY ASSESSMENT THUNDER BAY TERMINALS

March, 1978

Ontario
Ministry of the Environment

PRE-OPERATIONAL
AIR AND WATER QUALITY ASSESSMENT
in the vicinity of
THUNDER BAY TERMINALS LIMITED

ONTARIO MINISTRY OF THE ENVIRONMENT
March, 1978

PREFACE

The investigations described in this report were conducted independently by the Air Quality Assessment Unit and the Water Resources Assessment Unit, Technical Support Section, of the Ministry's Regional Office in Thunder Bay. The air quality data cover the period January to December, 1976, while those pertaining to water quality were obtained between March, 1975, and October, 1976. For the convenience of readers, the table of contents and summary, which immediately follow this preface, include information relating to both investigations. The remainder of the report is divided into two separate parts, one on air quality and one devoted to water quality studies.

CONTENTS

SUMMARY

AIR QUALITY

In 1975, pre-operational air quality studies were started in the vicinity of a proposed coal storage transfer facility (Thunder Bay Terminals Limited). This report presents results from investigations in 1976, which included snow sampling and air monitoring surveys.

A 39-site snow sampling study in January, 1976, confirmed results obtained in 1975, and indicated that significantly elevated concentrations of iron and arsenic occurred in snow near two industrial sources of particulate emissions south of the Thunder Bay Terminals site. Aluminum and sulphate were also slightly elevated in the same areas. Concentrations of these elements were normal in snow on land at Thunder Bay Terminals and in adjacent urban areas of the City of Thunder Bay.

Dustfall levels were generally similar in 1975 and 1976. Highest dustfall occurred in the immediate vicinity of coal piles at Ontario Hydro's thermal generating station. Dustfall and suspended particulate concentrations at the Thunder Bay Terminals site were susually below Ontario criteria and similar to those recorded at a nearby Ministry of the Environment monitoring location at McKellar Hospital in the urban part of the City.

WATER QUALITY

In 1975 and 1976, a water quality survey was conducted in Thunder Bay Harbour in the vicinity of McKellar Island to document baseline chemical data prior to the start of coal handling operations at Thunder Bay Terminals Limited. Results indicated that iron levels at 7 of the 10 sampling sites exceeded the Ontario criteria for public surface water supplies and the protection of fish and aquatic

life. However, natural levels of iron recorded in previous surveys upstream of industrial and waste discharges indicate that background concentrations of this element also exceed the desired objectives.

Although problems of excessive aquatic plant growth were not documented in this survey, elevated phosphorus levels capable of supporting nuisance levels of algae were recorded at the river sampling stations. Phosphorus levels at offshore sampling sites were considerably lower but still in excess of values observed in the uncontaminated near-shore waters of Lake Superior.

PART A. AIR QUALITY

INTRODUCTION

In 1975, the Ontario Ministry of the Environment began pre-operational air quality studies in the vicinity of a site designated for a coal storage and transfer facility owned and operated by Thunder Bay Terminals Limited. Operational start-up of the terminal is scheduled for late 1978. Since the location of this project, on McKellar Island at the mouth of the Kaministikwia River, Thunder Bay harbour, was close to two other existing potential sources of industrial air pollution, the latter were also included in the study programme.

Since coal dust is the airborne contaminant of main interest at Thunder Bay Terminals, investigations were centred on the nature and present levels of particulate matter in the area. The Ministry's permanent air monitoring network has provided some of the required information, but special studies were required to obtain detailed data around the project site. A sampling study was conducted in January and March, 1975, to determine background concentrations of selected parameters in surface snow on McKellar Island, in adjacent residential-commercial areas of the City of Thunder Bay, and around two nearby potential sources of particulate matter; coal piles at Ontario Hydro's 100-megawatt thermal generating station, and stored materials (mainly iron pellets) at a bulk handling facility operated by Valley Camp Limited. The 1975 snow survey showed that concentrations of all parameters examined were uniformly low at the Thunder Bay terminals site, but that significantly elevated levels of arsenic and iron were present in snow in the vicinity of Valley Camp Limited (1). Beginning in April, 1975, dustfall and suspended particulate monitoring was undertaken by

V. B. Cook Limited, project managers for Thunder Bay Terminals. This work revealed that dustfall near coal piles at Ontario Hydro was often above the Ontario criterion, but that suspended particulate levels were generally low (2). The final phase of the 1975 assessment programme was a vegetation and soil sampling survey in July, which demonstrated that levels of aluminum, arsenic and iron in local vegetation and soil were within the range considered normal for urban areas (2).

SNOW SAMPLING

Snow sampling has been found useful as an indicator of the kind, amount and extent of pollutant deposition around industrial sources of particulate emissions. The adverse environmental effects, if any, of the presence of some contaminants in snow has not yet been established, nor have regulations been developed to define acceptable levels of snow pollution. However, based on a number of northern Ontario surveys, guidelines have been established for concentrations of several elements in snow.

The 1975 survey, comprising 22 sample points, was expanded to 39 stations, plus controls, in 1976. Snow was collected on January 20-21, 1976. Most sample sites were located south of the Thunder Bay Terminals site, near particulate emission sources on the properties of Valley Camp Limited and Ontario Hydro (Figure 1). Sampling and sample processing techniques were the same as those used in the first survey (1), except that the volume of each sample was fixed at an approximate surface area of 50 by 50 cm (centimetres) and a depth of 20 cm. The organic and inorganic carbon content of submitted samples was determined by the Water Quality Section, Laboratory Services Branch, using infra-red spectrophotometry. All other analyses were performed at the Ministry's Thunder Bay Regional Laboratory; aluminum was

determined by atomic absorption spectrophotometry, arsenic by flameless atomic absorption spectrophotometry, iron by ortho-phenanthroline colorimetry, and sulphate by methyl thymol blue colorimetry.

Total snow depth at sample sites in the survey area averaged 44 cm on January 20. Depth of fresh snow (that which fell in the 10-day period before sampling) was about 19 cm, or 95% of each sample. Reddish or greyish particulate matter (possibly iron oxide dust) was observed on or below the snow surface at sites on Mission Island closest to Valley Camp and at sites 26 to 32 on Valley Camp property. Black-coloured particulate (probably coal dust) was noted in snow at sites 20 to 22 and site 24 near Ontario Hydro's coal piles. Other sites in the survey area yielded clean snow.

Chemical analysis results are shown in Table 1, in which sampling stations are listed by groups as follows: sites 1 to 3 in the residential-commercial area of Thunder Bay; sites 4 to 6 on McKellar Island, near the Thunder Bay Terminals project; sites 7 to 17, and 25, on Mission Island, under the potential influence of particulate emissions from Valley Camp; sites 18 to 24, under the potential influence of dust from Ontario Hydro's coal piles; sites 26 to 39, on Valley Camp property; and control sites 40 and 41, both about 25 km (kilometres) west of the study area.

Significantly elevated concentrations of arsenic and iron (Figures 3 and 4, respectively) were found in snow on or near Valley Camp property. The presence of these contaminants was attributed to dust emissions from the handling of iron pellets stored on Company property. Minor sources of these pollutants appeared to be coal storage areas at Ontario Hydro. The control value for arsenic at station 40 was considered an anomaly and

was attributed to a local, unidentified source of contamination. Slightly elevated levels of aluminum and sulphate were also evident near Valley Camp and Ontario Hydro (Figures 2 and 5). Concentrations of aluminum, arsenic, iron and sulphate decreased with increasing distance from emission sources. Contamination guidelines of 2 mg/l (milligrams per litre) for aluminum, 25 µg/l for arsenic, 5 mg/l for iron, and 10 mg/l for sulphate were exceeded at one or more sample sites. No relationship could be established between carbon levels and distance from a known source, although elevated carbon concentrations were recorded at scattered points throughout the survey area. Values for snow meltwater pH ranged from 2.9 to 6.0, similar to the range of 3.0 to 5.0 normally found for uncontaminated snow. Only three values exceeded 5.0, and all these were at sites on Valley Camp property which might have been influenced by proximity to stored alkaline materials.

AIR MONITORING

DUSTFALL

Dustfall comprises particulate matter which settles out from the atmosphere under the influence of gravity. It is measured by exposing open-top vessels for 30 days and weighing the collected matter. Results are expressed in tons per square mile per month.

Figure 6 shows the location of dustfall monitoring sites and Table 2 summarizes dustfall results for 1976, based on data furnished by V. B. Cook Co. Ltd. For comparison, dustfall values at one of the Ministry of the Environment stations (site 9, Figure 6) are also included. Dustfall on McKellar Island (sites 1-3) was similar to that for adjacent parts of Thunder Bay. Much higher levels were recorded at sites 4 to 8, near Ontario Hydro's coal storage area, where the Ontario monthly and annual criteria for dustfall were frequently exceeded. High dustfall in this area was,

however, very localized and did not extend beyond the immediate vicinity of the generating station. Dustfall levels in 1975 and 1976 were generally similar.

SUSPENDED PARTICULATE

Suspended particulate constitutes particulate matter of small size which remains in the atmosphere for extended periods. In the high-volume method of suspended particulate monitoring, a measured volume of air is drawn through a pre-weighed glass fibre filter for 24 hours. Samplers are normally operated every sixth day. Exposed filters are reweighed to determine the quantity of matter collected. Results are expressed in micrograms per cubic metre of air ($\mu g/m^3$).

Complete monitoring results for 1976 are given in Table 3 for sites 1 to 3 (Figure 6) operated by V. B. Cook Co. Ltd. For comparison, data from a nearby Ministry of the Environment station (site 9, Figure 6) are also included. Values above the Ontario criterion (120 $\mu g/m^3$, 24-hour average) were recorded at all locations, although the annual geometric means were well within the provincial criterion (60 $\mu g/m^3$) for three of the sites. The annual criterion was slightly exceeded (by 1 $\mu g/m^3$) at site 2. There was good general agreement between particulate concentrations at the Ministry's station (site 9) and those at sites 1 and 3. Prevailing wind directions, recorded at site 3, were also very similar to those reported by the Thunder Bay Airport weather station, about 9 km to the west.

ACKNOWLEDGEMENT

We are grateful to Messrs. V. B. Cook Co. Limited for providing data on dustfall, suspended particulate and wind directions.

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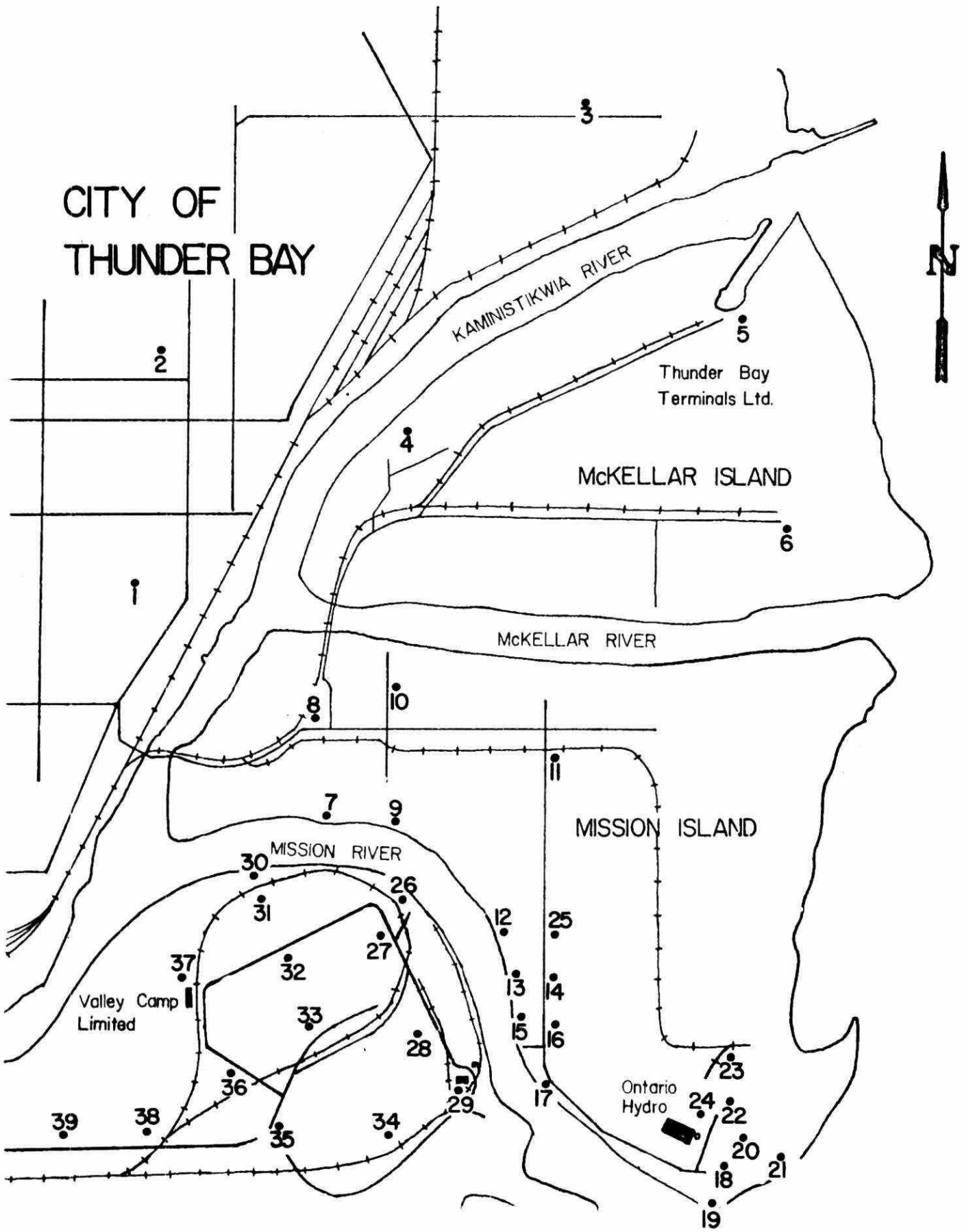
THUNDER BAY TERMINALS

0 400 800

metres

Figure 1. Snow sampling sites, January, 1976.



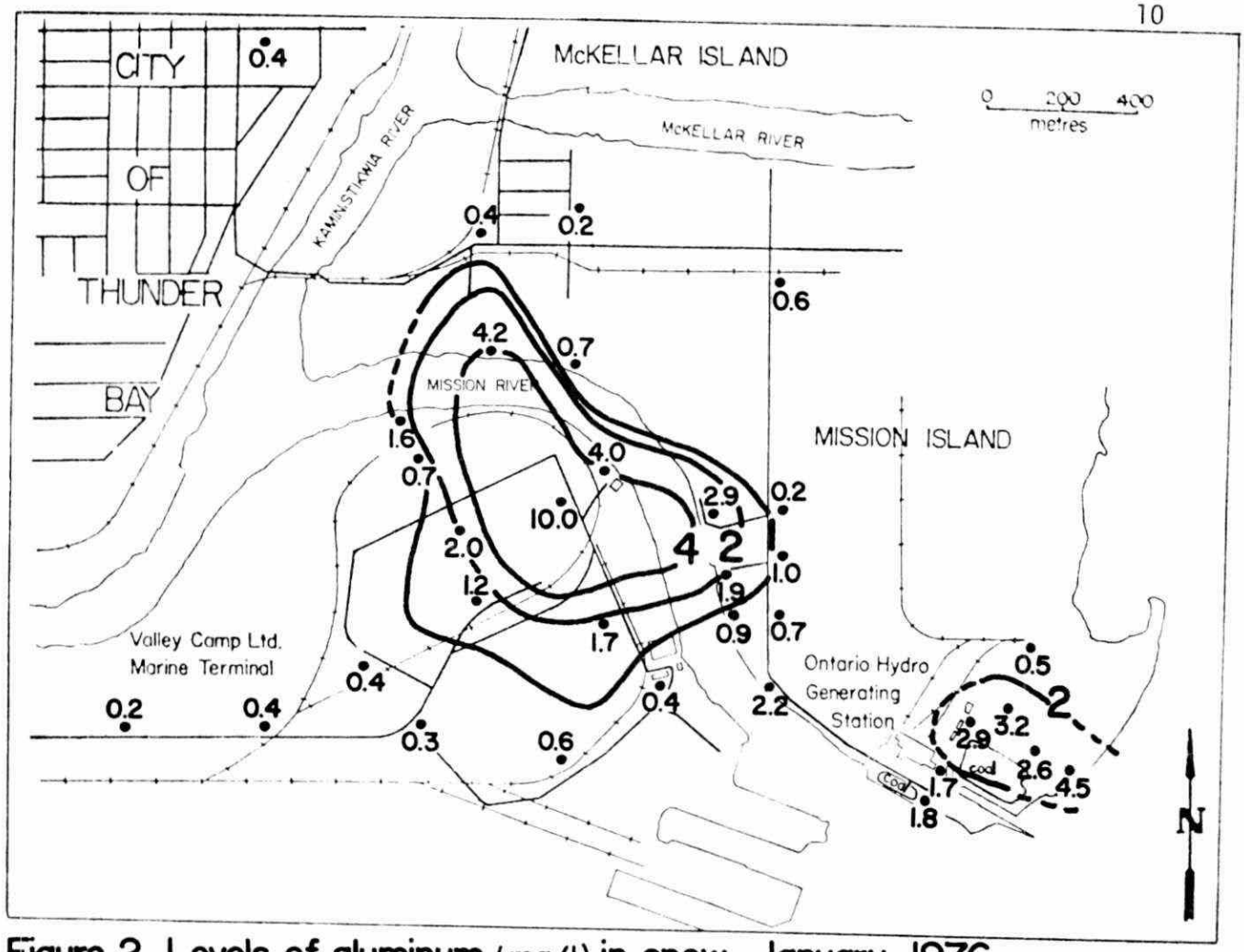


Figure 2. Levels of aluminum (mg/l) in snow, January, 1976.

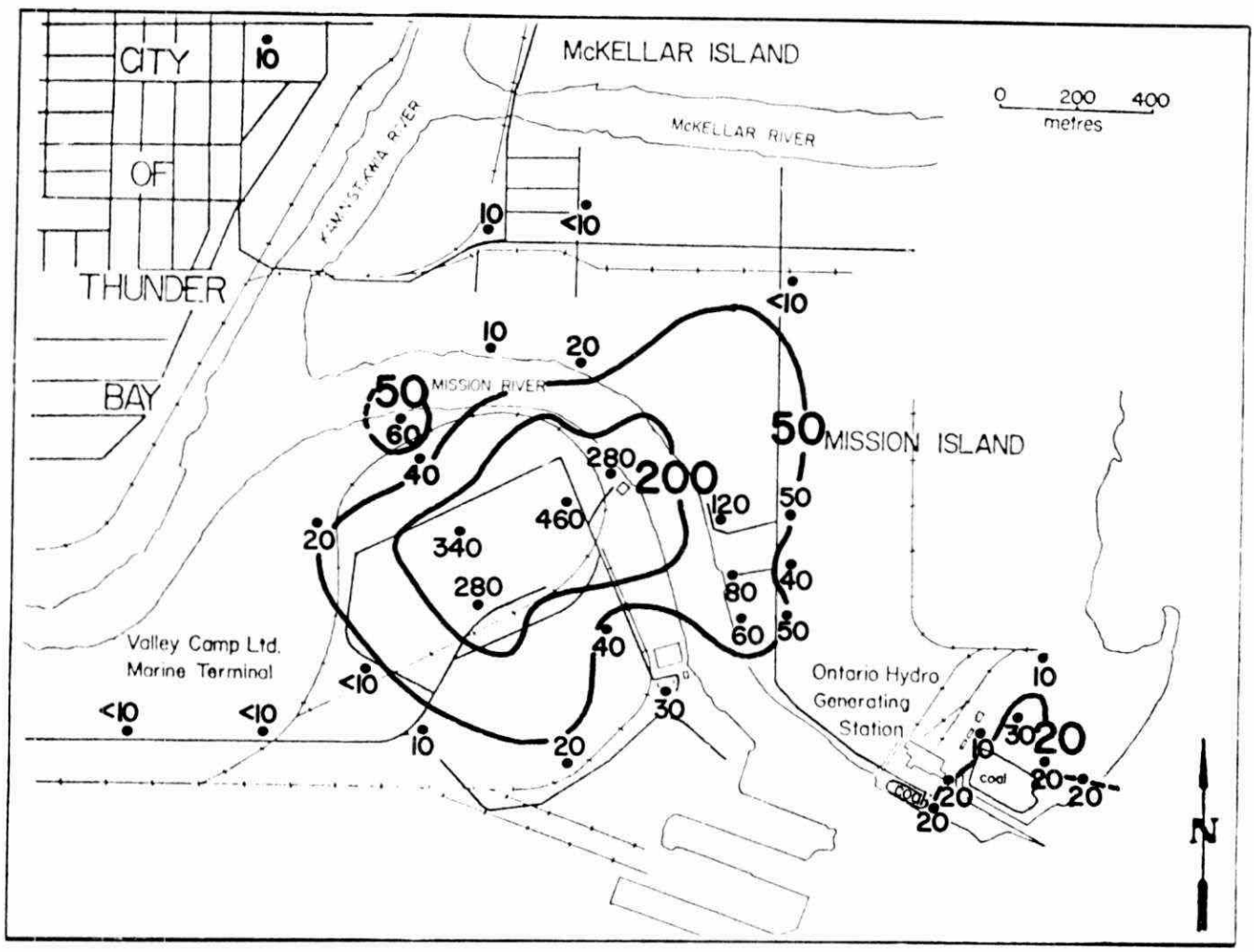


Figure 3. Levels of arsenic (µg/l) in snow, January, 1976.

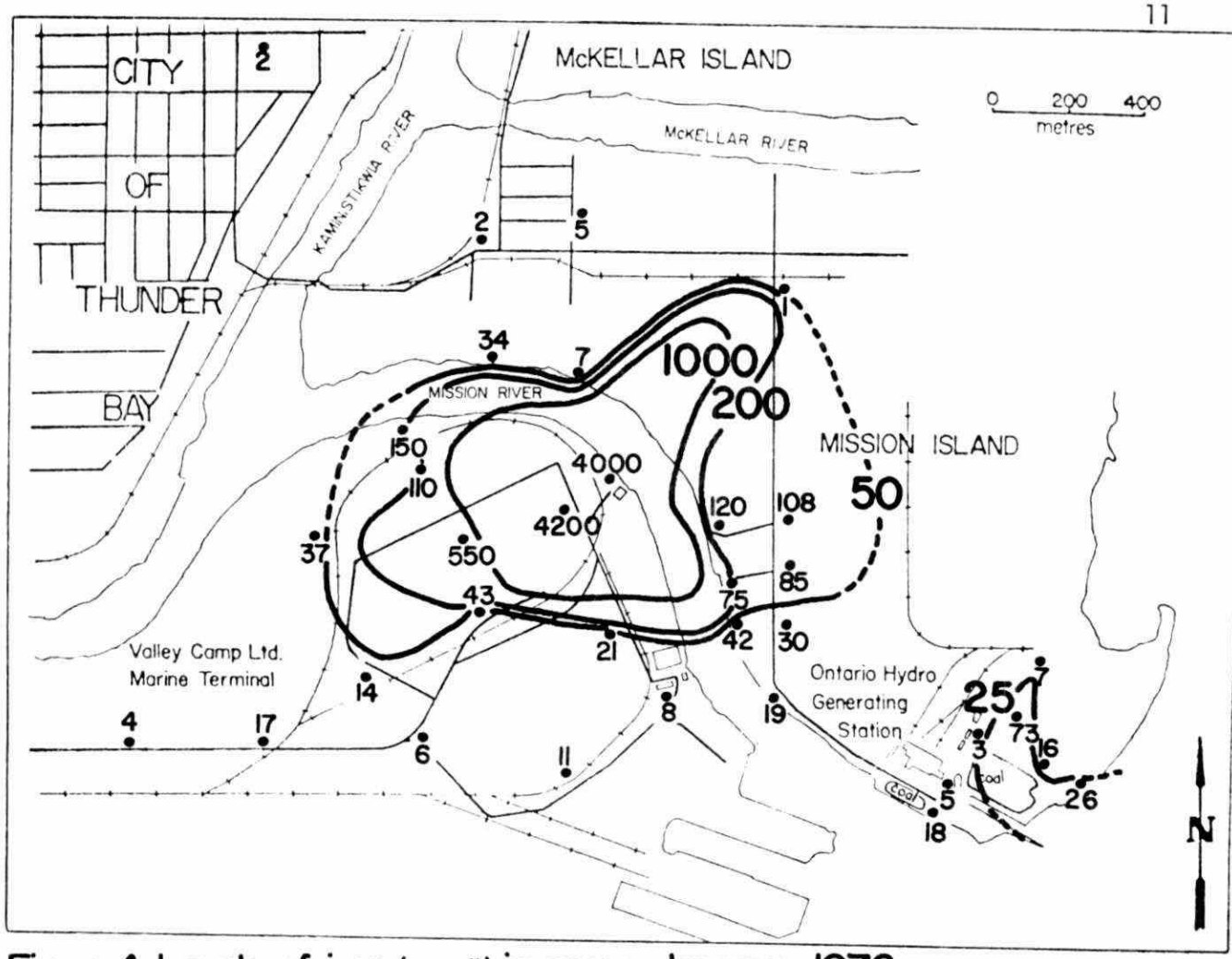


Figure 4. Levels of iron (mg/l) in snow, January, 1976.

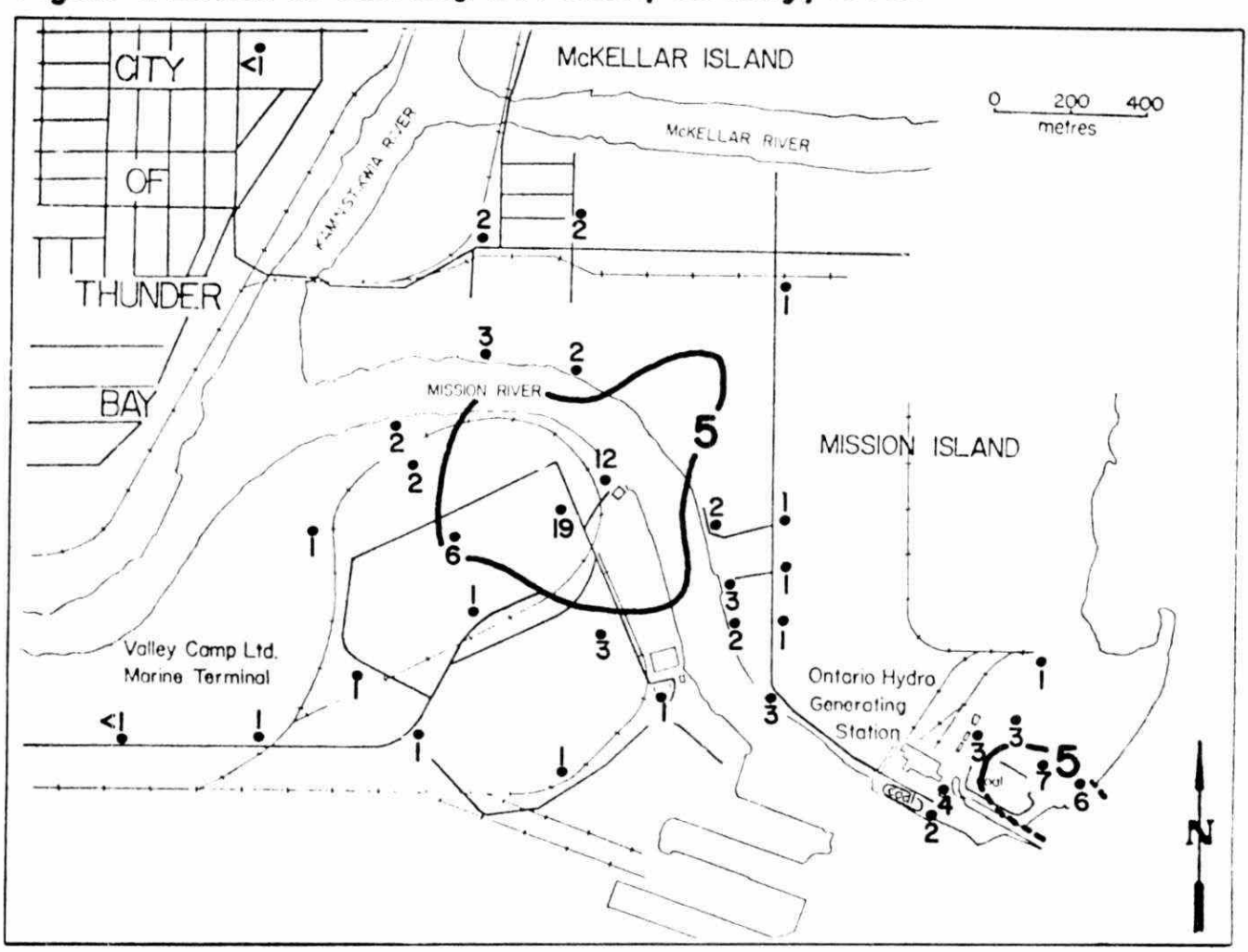


Figure 5. Levels of sulphate (mg/l) in snow, January, 1976.

THUNDER BAY TERMINALS

0 400 800

metres

Figure 6. Air monitoring sites, 1976.

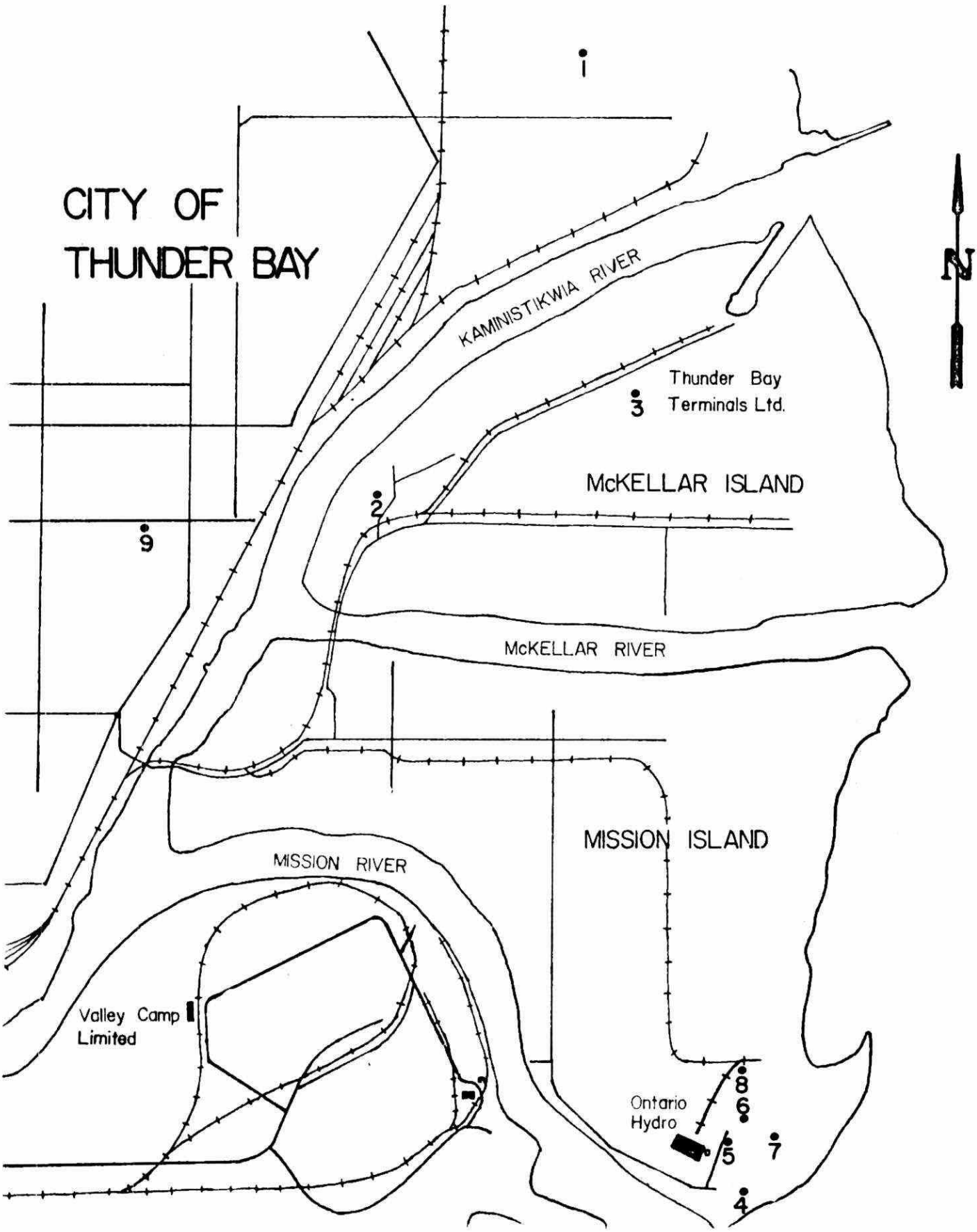


TABLE 1. Levels of aluminum, arsenic, total carbon, iron, sulphate (all in mg/l) and pH in snow collected near Ontario Hydro, Thunder Bay Terminals Limited and Valley Camp Limited on January 20-21, 1976

Station number	Aluminum	Arsenic	Carbon	Iron	Sulphate	pH
1	0.4	<0.01	8	2	<1	3.0
2	0.3	<0.01	1	<1	<1	3.1
3	0.3	0.16	2	1	<1	3.3
4	0.2	0.03	2	<1	2	3.5
5	0.3	0.09	3	1	2	3.6
6	0.1	<0.01	2	<1	1	3.6
7	4.2	0.01	10	34	3	3.5
8	0.4	0.01	44	2	2	4.5
9	0.7	0.02	4	7	2	3.6
10	0.2	<0.01	12	5	2	3.6
11	0.6	<0.01	4	1	1	3.5
12	2.9	0.12	2	120	2	3.7
13	1.9	0.08	3	75	3	3.4
14	1.0	0.04	5	85	1	3.4
15	0.9	0.06	3	42	2	3.4
16	0.7	0.05	3	30	1	3.4
17	2.2	0.02	7	19	3	4.8
25	0.2	0.05	4	108	1	3.5
18	1.7	0.02	3	5	4	4.4
19	1.8	0.02	5	18	2	3.4
20	2.6	0.02	9	16	7	3.5
21	4.5	0.02	5	26	6	4.9
22	3.2	0.03	2	73	3	3.9
23	0.5	0.01	2	7	<1	3.0
24	2.9	0.01	4	30	3	4.9
26	4.0	0.28	8	4000	12	5.6
27	10.0	0.46	6	4200	19	6.0
28	1.7	0.04	3	21	3	5.2
29	0.4	0.03	3	8	1	3.7
30	1.6	0.06	4	150	2	3.6
31	0.7	0.04	5	110	2	3.5
32	2.0	0.34	5	550	6	4.8
33	1.2	0.28	2	43	1	3.5
34	0.4	0.02	5	11	1	3.3
35	0.3	0.01	2	6	1	3.1
36	0.4	<0.01	3	14	1	3.2
37	0.4	0.02	4	37	1	3.7
38	0.4	<0.01	<1	17	1	3.1
39	0.2	<0.01	8	4	<1	3.2
40 (control)	0.1	0.12	1	<1	<1	2.9
41 (control)	0.1	0.02	<1	<1	<1	2.9

TABLE 2. Dustfall (tons/square mile/30 days) in the vicinity of Thunder Bay Terminals and Ontario Hydro, 1976.

Site	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1	Sewage treatment plant	7	3	10	9	20	16	7	11	6	10	8	5	9
2	Shell Oil plant	9	4	9	15	16	19	13	11	15	10	12	9	12
3	Thunder Bay Terminals	7	7	8	6	11	10	12	13	7	15	37[a]	10	12
4	Ontario Hydro (SE)	6	3	6	32	11	39	11	8	4	6	12	10	12
5	Ontario Hydro (SW)	16	10	13	31	168	34	38	11	8	14	20	19	32
6	Ontario Hydro (NW)	13	4	11	7	24	24	16	24	24	10	12	12	15
7	Ontario Hydro (NE)	57	10	15	37	101	71	80	14	13	6	43	10	38
8	Ontario Hydro (N)							57	25	8	13	10	9	20
9	McKellar Hospital	3	8	16	21	15	14	7	10	8	8	5	10	10

[a]Values exceeding criteria of 20 (monthly) or 13 (annual average) are underlined.

TABLE 3. Levels of suspended particulate ($\mu g/m^3$) in the vicinity of Thunder Bay Terminals, 1976.

Date		Sampling site 1	2	3	9	Date		Sampling site 1	2	3	9
Jan	1	17	23	15	18	Jul	5	32	-	94	127
	7	12	21	17	15		11	35	-	39	73
	13	18	30	19	14		17	-	86	41	29
	19	63	64	57	41		23	41	102	102	-
	25	26	31	25	24		29	64	124	122	82
	31	19	15	15	13						
						Aug	4	87	169	66	73
Feb	6	16	20	21	15		10	56	112	63	135
	12	50	60	168[a]	55		16	8	110	79	72
	18	16	16	13	49		22	56	95	58	42
	24	56	70	51	51		28	194	339	189	153
Mar	1	28	28	25	24	Sep	3	83	139	124	86
	7	23	7	8	18		9	48	78	128	47
	13	19	25	18	103		15	49	88	78	95
	19	37	49	35	40		21	17	28	15	23
	25	19	30	9	25		27	25	73	34	-
	31	52	45	4	58						
						Oct	3	44	75	42	51
Apr	6	55	64	63	113		9	46	82	45	38
	12	69	147	64	119		15	128	130	99	111
	18	11	25	14	27		21	9	36	37	23
	24	51	133	40	88		27	122	161	186	-
	30	60	83	56	-						
						Nov	2	132	176	148	144
May	6	42	72	46	49		8	74	155	119	117
	12	70	135	79	117		14	91	64	101	39
	18	91	123	72	156		20	34	54	78	49
	24	32	51	30	46		26	36	54	91	28
	30	86	112	84	99						
						Dec	2	45	62	136	28
Jun	5	78	114	74	171		8	25	42	108	23
	11	50	51	28	48		14	35	62	41	24
	17	19	26	47	46		20	25	34	47	28
	23	79	99	67	99		26	10	25	28	20
	29	50	-	40							
				Annual geometric means				41	61	47	49

[a]Values above criterion (120 $\mu g/m^3$, 24-hour average) are underlined.

PART B. WATER QUALITY

INTRODUCTION

Until recently, the Great Lakes were often assumed to have unlimited assimilative capacities; however, with the deterioration of Lake Erie and to a lesser extent Lake Ontario, it has become obvious that such an assumption is unfounded, and that careful management of industrial and municipal activities is necessary to maintain or restore the water quality of the Great Lakes (1).

In 1975 and 1976, a water quality survey was conducted in Thunder Bay Harbour in the vicinity of McKellar Island, the site of the proposed Thunder Bay Terminals coal handling facilities. This survey provided a measure of general water quality in the vicinity of the coal terminal, and a baseline reference for post-operational surveys.

DESCRIPTION OF STUDY AREA

The source of the Kaministikwia River is Dog Lake, located approximately 40 km (kilometres) northwest of the City of Thunder Bay. Major tributaries of the Kaministikwia River are the Shebandowan, Whitefish and Slate Rivers. The river flows in a southerly and then easterly direction to Thunder Bay. Approximately 1.3 km from its mouth, the river divides into three channels (Figure 1), the Kaministikwia, McKellar and Mission Rivers. The percentage of the total flow entering the bay from each of the three channels is estimated to be: Mission River, 42%; McKellar River, 18%; and the Kaministikwia River, 40% (2).

McKellar Island, one of two islands located in the river delta, is the site of the Thunder Bay Terminals coal handling facility now under construction. The island is approximately 242 ha (hectares) in size and is bounded on the north by the Kaministikwia River, on the south by the McKellar River, and on the east by Thunder Bay harbour (2).

FIELD METHODS

Monthly sampling of 10 sites located in the vicinity of McKellar Island (Figure 1) began in March, 1975 and concluded in October, 1976.

Samples were collected from one metre below the surface using either a plastic 4-litre Van Dorn water sampler or a plastic 2-litre Kemmerer water sampler. Samples for heavy metal analysis were placed in 1-litre plastic bottles and preserved with 2 ml (millilitres) of nitric acid (HNO_3); samples for other chemical parameters were collected in 1-litre glass bottles with no preservatives added. All samples were submitted on the day of collection to the Thunder Bay Regional Laboratory. Barium, boron, chromium, lithium, manganese, selenium, silica, strontium and vanadium determinations were performed by the Ministry of the Environment Laboratory, Toronto. All other analyses were carried out at the Ministry's Thunder Bay Regional Laboratory, generally on the day following sample submission.

RESULTS AND DISCUSSION

Water quality in the study area is affected by industrial and municipal discharges, fluctuating river flows, and by the mixing effects of Lake Superior.

Concentrations of non-metallic parameters analyzed in this survey were all within provincial guidelines and criteria (3) for public surface waters and the protection of fish and aquatic life (Tables 1-4). In 1975, concentrations of barium, boron, chromium, lithium, manganese, selenium, silica, strontium and vanadium were found to be either below detection limits or occurred at very low levels. Analysis of these parameters was therefore not repeated in 1976. Although phosphorus levels were elevated in the lower Kaministikwia River, no nuisance levels of plant growth were detected. Phosphorus levels at stations 6 and 7 were lower than those recorded in the river, due to the diluting effect of Lake Superior; however, the values at these stations were still in excess of levels, < 0.01 mg/l (milligrams per litre), observed in uncontaminated near-shore waters of Lake Superior (1).

Iron, the most abundant of the heavy metals, was the only metallic parameter to exceed the provincial criterion for public surface waters and the protection of fish and aquatic life. Iron is reported to have a low order of toxicity to animal life (4), as its toxicity is dependent on its valence state, and whether it occurs in solution or suspension. Because the relative concentrations of these iron compounds are constantly changing, only total iron is reported. Iron levels in this survey exceeded the criterion of 0.3 mg/l at stations 1, 2, 3, 4, 8, 9 and 10. Values at these sites ranged from 0.42 to 1.20 mg/l. However, iron concentrations recorded in previous surveys upstream of industrial and waste discharges indicate that iron levels are naturally higher in the Kaministikwia River, with a mean of 0.72 mg/l.

CONCLUSIONS

Interpretation of the water quality data obtained in this survey, with respect to possible contamination from the Thunder Bay Terminals site, is complicated by the numerous upstream point

source loadings (5), fluctuating river flows and the mixing influence of Lake Superior. This survey provides a measure of general water quality in the lower Kaministikwia River for use as a baseline reference for post-operational surveys. Changes in upstream pollution sources, which may be significant, will have to be considered in interpreting data from future studies.

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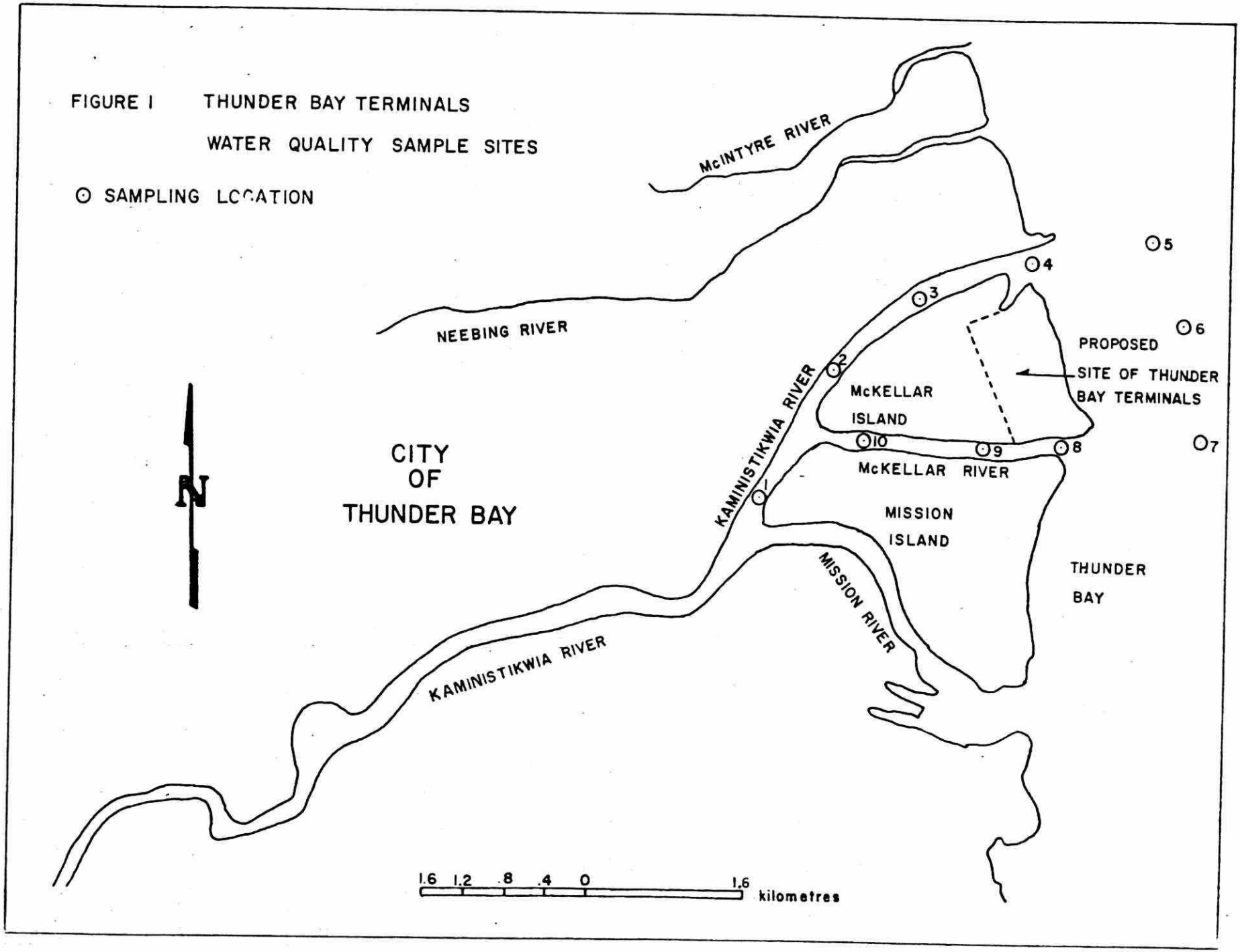
FIGURE I THUNDER BAY TERMINALS
WATER QUALITY SAMPLE SITES
⊙ SAMPLING LOCATION
McINTYRE RIVER
NEEBING RIVER
KAMINISTIKWIA RIVER
CITY
OF
THUNDER BAY
N
McKELLAR
ISLAND
PROPOSED
SITE OF THUNDER
BAY TERMINALS
McKELLAR RIVER
MISSION
ISLAND
MISSION RIVER
THUNDER
BAY
KAMINISTIKWIA RIVER
1.6 1.2 .8 .4 0 1.6
kilometres

TABLE 1. Mean concentrations[a] of selected non metallic water quality parameters in the vicinity of the proposed coal handling facility of Thunder Bay Terminals Ltd., March, 1975 to October, 1975.

	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
Parameters	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
BOD_5	7.91	8	5.81	6.28	8	4.77	5.26	8	4.72	3.16	8	1.89	1.37	7	.752	1.49	7	.598	1.29	7	.381	4.36	8	3.00	4.39	7	2.79	5.09	8	2.96
Susp. Solids	11.88	8	9.98	12.25	8	11.85	9.13	8	10.64	8.63	8	10.90	3.57	7	1.62	3.71	7	1.70	3.14	7	1.86	6.63	8	7.60	5.57	7	3.36	11.38	8	13.97
Cond.[b]	134.6	8	20.98	129.8	8	11.99	126.9	8	9.82	120.0	8	8.93	106.4	7	5.88	103.0	7	3.46	101.4	7	4.50	123.3	8	9.18	126.4	7	12.87	128.4	8	13.42
Turbidity[c]	8.73	8	11.49	8.76	8	11.63	7.86	8	9.49	7.53	8	10.46	3.30	7	2.07	2.71	7	1.84	2.13	7	.772	7.90	8	11.39	3.64	7	.955	8.79	8	12.70
Free NH_3	< .064	8	.088	< .106	8	.121	< .183	8	.277	< .103	8	.163	< .043	7	.039	< .043	7	.039	< .024	7	.013	< .124	8	.126	< .077	7	.091	< .085	8	.082
Total K	.716	8	.074	.764	8	.205	.886	8	.279	.591	8	.283	.305	7	.099	.280	7	.111	.224	7	.061	.824	8	.557	.587	7	.081	.643	8	.178
Nitrite	.009	8	.005	.011	8	.006	.016	8	.024	.009	8	.005	.005	7	.003	.005	7	.002	.005	7	.002	.009	8	.006	.007	7	.002	.009	8	.006
Nitrate	< .037	7	.036	< .039	8	.036	< .041	8	.038	< .063	8	.041	.100	7	.018	.104	7	.015	.104	7	.016	< .041	8	.023	< .030	7	.031	< .034	8	.029
Total P	.064	7	.024	.075	7	.024	.114	7	.078	.059	7	.037	.021	7	.011	.019	7	.012	.028	7	.041	.064	7	.038	.051	6	.004	.061	7	.023
Diss. Reac. P	.015	8	.007	.016	8	.011	.052	8	.090	.015	8	.014	.007	7	.005	.006	7	.006	.013	7	.024	.019	8	.023	.018	7	.027	.013	8	.009
Chloride	< 8.25	8	5.47	< 6.63	8	4.21	< 6.13	8	3.23	< 5.00	8	2.83	< 3.00	7	2.83	< 1.86	7	.690	< 1.86	7	1.07	< 4.50	8	2.98	7.43	7	2.37	7.13	8	3.18
Hardness	55.63	8	5.68	53.88	8	3.60	< 54.1	8	3.36	52.75	8	4.86	48.71	7	2.63	48.71	7	5.12	48.14	7	3.29	53.25	8	3.88	53.29	7	3.73	53.38	8	4.59
Alkalinity	41.50	8	3.21	43.63	8	4.57	44.0	8	4.31	46.00	8	3.96	45.14	7	2.73	44.57	7	3.26	44.00	7	2.52	43.13	8	3.27	42.43	7	3.69	43.50	8	3.78

TABLE 1. (Continued)

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
Acidity	3.71	7	2.06	3.71	7	.628	3.00	7	1.29	2.57	7	1.39	2.00	7	1.00	1.71	7	.488	2.00	7	1.00	3.29	7	2.06	2.83	6	1.83	3.29	7	2.06
pH (Lab.)[d]	6.34	8	.233	6.53	8	.362	6.54	8	.297	6.70	8	.298	7.07	7	.256	7.13	7	.229	7.17	7	.256	6.66	8	.267	6.56	7	.269	6.65	8	.298
Colour[e]	>56.88	8	24.34	>48.13	8	26.45	>45.0	8	27.9	>34.4	8	24.6	<16.43	7	10.69	<15.71	7	11.34	<20.71	7	23.35	>40.0	8	26.59	>39.3	7	23.88	>46.8	8	26.31
Silica	2.41	7	.667	2.16	7	.690	2.03	7	.716	1.78	6	.560	1.40	6	.442	1.33	6	.441	1.28	6	.453	2.10	7	.705	2.14	7	.721	2.11	7	.669
COD	< 68.75	8	42.57	<56.25	8	36.13	< 45.0	8	33.7	< 36.2	8	31.7	< 22.1	7	19.12	<17.86	7	13.49	<18.57	7	18.64	< 46.3	8	40.25	53.57	7	43.18	< 58.1	8	47.28
Sulphates	10.86	8	3.60	8.38	8	3.07	7.31	8	2.99	6.06	8	2.46	3.71	7	1.38	3.50	7	1.32	4.00	7	1.15	7.38	8	2.19	7.21	7	2.04	7.81	8	2.48
Arsenic[f]	< 2.06	7	1.93	< 1.74	7	.761	< 1.84	7	1.19	< 2.03	7	1.77	< 1.01	7	.038	< 2.57	7	2.69	< 1.13	7	.222	< 1.06	7	.151	< 1.00	6	0	< 1.06	7	.151
Boron	< .032	6	.018	< .026	6	.012	< .030	6	.011	< .027	6	.012	< .030	6	.016	< .028	6	.013	< .026	6	.012	< .042	6	.026	< .037	6	.021	< .038	6	.028
Selenium	< .001	8	.000	< .001	8	.000	< .001	8	.000	< .001	8	.000	< .001	7	.000	< .001	7	.000	< .001	7	.000	< .001	8	.000	< .001	7	.000	< .001	8	.000

[a]All parameters reported in mg/l except where noted: b - µmhos/cm; c - Formazin Turbidity Unit; d - pH units; e - Hazen Units; f - µg/l

n - Number of values

s - Standard deviation

$\bar{x}$ - Mean values

TABLE 2. Mean concentrations[a] of selected metallic water quality parameters in the vicinity of the proposed coal handling facility of Thunder Bay Terminals Ltd., March, 1975 to October, 1975.

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
Total iron	.938	8	-	1.20	8	1.91	.759	8	.953	.682	8	.989	.232	7	.135	.269	7	.242	.149	7	.062	.626	8	.721	.416	6	.148	.765	7	.869
Copper	.011	8	.008	< .013	8	.010	< .012	8	.006	.023	8	.019	< .015	7	.017	< .007	7	.004	.021	7	.026	< .010	8	.007	< .010	7	.007	< .014	8	.008
Nickel	< .011	8	.008	< .010	8	.007	< .010	8	.007	< .013	8	.008	< .007	7	.006	< .005	7	.003	< .007	7	.007	< .013	8	.009	< .011	7	.007	< .015	8	.013
Zinc	.010	8	.007	< .012	8	.011	< .011	8	.009	< .009	8	.010	< .004	7	.003	< .005	7	.004	< .003	7	.002	< .009	8	.007	< .010	7	.013	< .012	8	.009
Calcium	14.75	8	1.49	14.38	8	1.99	14.25	8	1.49	14.50	8	.755	13.71	7	1.25	14.00	7	.577	14.71	7	1.50	14.00	8	1.07	14.86	7	1.07	14.00	8	2.27
Magnesium	4.88	8	1.46	4.38	8	1.60	4.38	8	1.30	4.13	8	1.13	3.71	7	1.25	3.29	7	1.25	2.71	7	1.25	4.38	8	1.51	3.86	7	1.22	4.38	8	1.77
Sodium	4.94	8	1.65	4.78	8	1.15	4.41	8	1.31	3.39	8	1.22	2.59	7	.546	2.13	7	.682	2.14	7	.745	3.61	8	1.23	3.94	7	1.75	4.07	8	1.55
Potassium	.944	8	.332	1.18	8	.372	1.17	8	.467	< .931	8	.614	.877	7	.575	< .764	7	.513	.629	7	.335	.963	8	.509	.700	7	.439	< .863	8	.512
Lead	< .019	8	.014	< .019	8	.014	< .021	8	.014	< .019	8	.014	< .015	7	.016	< .011	7	.006	< .009	7	.005	< .022	8	.015	< .016	7	.012	< .019	8	.014
Cadmium	< .004	7	.004	< .005	7	.004	< .005	7	.004	< .005	7	.004	< .004	6	.004	< .002	6	.002	< .002	6	.002	< .005	7	.004	< .004	6	.003	< .005	8	.004
Mercury	< .118	8	.093	< .109	8	.068	< .194	8	.224	< .089	8	.053	< .127	7	.158	< .160	7	.168	< .107	7	.066	< .168	8	.191	< .130	7	.131	< .075	8	.020
Manganese	< .039	7	.015	< .040	8	.028	< .033	8	.019	< .028	8	.023	< .017	7	.008	< .014	7	.005	< .010	7	.000	< .034	8	.018	< .030	7	.012	< .031	8	.013
Vanadium	< .024	8	.023	< .023	8	.023	< .020	8	.023	< .024	8	.023	< .016	7	.005	< .016	7	.005	< .016	7	.005	< .024	8	.023	< .026	7	.024	< .024	8	.023
Barium	< .021	8	.006	.026	8	.015	< .020	8	.008	< .019	8	.014	< .016	7	.005	< .013	7	.005	< .013	7	.005	< .015	8	.005	< .019	7	.007	< .019	8	.009

TABLE 2. (Continued)

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
Strontium	<	.044	8	.035	<	.040	8	.037	<	.041	8	.037	<	.040	8	.037	<	.043	7	.039	<	.043	7	.039	<	.043	7	.039	<	.040	8	.037	<	.044	7	.039	<	.040	8	.037
Lithium	<	.010	8	.003	<	.011	8	.004	<	.010	8	.000	<	.001	8	.000	<	.010	7	.000	<	.010	7	.000	<	.010	7	.000	<	.010	8	.000	<	.010	7	.000	<	.010	8	.000
Chromium	<	.035	8	.012	<	.035	8	.012	<	.035	8	.012	<	.035	8	.012	<	.033	7	.011	<	.033	7	.011	<	.033	7	.011	<	.035	8	.012	<	.037	7	.011	<	.035	8	.012

[a]All parameters reported in mg/l except for mercury, which is reported in µg/l (micrograms per litre).
n - Number of values
s - Standard deviation
$\bar{x}$ - Mean values

TABLE 3. Mean concentrations[a] of selected non metallic water quality parameters in the vicinity of the proposed coal handling facility of Thunder Bay Terminals Ltd., January, 1976 to October, 1976.

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
BOD_5	11.53	7	8.47	7.49	7	4.89	9.43	7	8.35	5.11	7	3.13	2.67	7	3.29	1.41	8	.772	1.31	8	.692	4.09	8	2.25	5.47	7	4.62	4.80	6	1.68
Susp. solids	6.14	7	2.73	8.00	7	4.62	8.00	7	4.62	6.43	7	3.51	5.43	7	6.60	2.75	8	1.49	2.88	8	1.81	4.38	8	2.88	5.14	7	2.34	5.83	6	2.04
Cond.[b]	142.3	7	37.42	132.9	7	31.05	130.0	7	32.49	124.7	7	24.53	103.6	7	13.23	101.1	8	9.06	99.13	8	12.92	118.4	8	25.03	122.9	7	25.10	120.0	6	18.29
Turbidity[c]	4.96	7	1.74	5.30	7	1.68	5.40	7	2.02	4.59	7	1.82	3.94	7	4.94	1.78	8	.905	1.85	8	.703	4.25	8	1.76	4.27	7	1.34	4.73	6	1.57
Free NH_3	< .021	7	.016	< .034	7	.052	< .036	7	.064	.077	7	.108	.050	7	.040	.038	8	.039	.039	8	.049	< .100	8	.158	.064	7	.091	< .035	6	.036
Total K	.679	7	.117	.750	7	.062	.683	7	.099	.691	7	.120	.367	7	.294	.349	8	.249	.386	8	.263	.673	8	.155	.636	7	.079	.692	6	.059
Nitrite	.007	7	.001	.006	7	.001	.006	7	.001	.005	7	.001	.004	7	.002	.004	8	.001	.004	8	.001	.006	8	.003	.006	7	.001	.007	6	.002
Nitrate	< .011	7	.004	< .011	7	.004	< .024	7	.034	< .024	7	.038	.084	7	.048	.090	8	.045	.081	8	.053	< .028	8	.032	< .029	7	.031	< .025	6	.019
Total P	.080	7	.099	.080	7	.024	.076	7	.031	.077	7	.029	.025	7	.019	.025	8	.028	.018	8	.012	.058	8	.021	.063	7	.023	.062	6	.023
Diss. Reac. P	.006	7	.002	.007	7	.003	.009	7	.006	.009	7	.005	.004	7	.003	.003	8	.003	.003	8	.002	.008	8	.006	.007	7	.006	.005	6	.002
Chlorides	10.86	7	5.08	8.86	7	4.09	8.29	7	4.92	7.00	7	3.51	< 2.86	7	1.95	< 2.25	8	1.98	< 2.50	8	1.93	6.25	8	3.62	6.86	7	3.58	6.67	6	3.01
Hardness	47.00	7	12.77	46.43	7	8.24	47.29	7	7.14	46.71	7	5.85	45.57	7	4.39	48.00	8	2.45	45.25	8	4.56	47.63	8	7.71	47.00	7	6.90	49.83	6	10.00
Alkalinity	37.71	7	2.93	39.71	7	4.46	40.29	7	5.62	41.57	7	5.50	44.29	7	5.59	44.38	8	2.62	42.13	8	5.62	41.38	8	6.63	40.86	7	5.37	41.17	6	4.22
Acidity	4.14	7	2.34	4.29	7	2.36	4.00	7	3.00	4.14	7	3.08	2.43	7	1.62	1.63	8	1.06	2.00	8	1.69	3.38	8	1.92	3.29	7	2.06	3.83	6	2.04
pH (Lab.)[d]	6.31	7	.385	6.34	7	.257	6.43	7	.368	6.49	7	.308	7.03	7	.229	7.14	8	.293	7.06	8	.354	6.53	8	.261	6.49	7	.212	6.48	6	.172

TABLE 3. (Continued)

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
Colour[e]	>67.1	7	7.56	>61.4	7	8.99	>53.6	7	23.22	>49.3	7	23.88	< 17.8	7	20.59	< 15.6	8	19.89	< 18.1	8	19.08	>41.3	8	21.00	>42.9	7	24.47	>45.8	6	20.10
COD	75.00	7	30.55	62.86	7	28.41	62.14	7	42.31	55.00	7	26.77	< 36.4	7	52.49	< 16.9	8	7.99	< 18.1	8	8.43	48.13	8	30.69	51.43	7	25.28	38.33	6	15.71
Sulphate	13.00	7	4.04	10.36	7	3.68	10.57	7	4.72	9.21	7	4.18	5.36	7	2.87	4.88	8	2.46	4.75	8	2.71	8.00	8	4.11	8.93	7	4.23	9.00	6	4.30
Arsenic[f]	< .010	7	.000	< .01	7	.00	< .01	7	.00	< .01	7	.00	< .01	7	.00	< .01	8	.00	< .01	8	.00	< .01	8	.00	< .013	7	.008	< .01	6	.00

[a]All parameters reported in mg/l except where noted:
n - Number of values
s - Standard deviation
$\bar{x}$ - Mean values
b - µmhos/cm
c - Formazin Turbidity Unit
d - pH units
e - Hazen Units
f - µg/l

TABLE 4. Mean concentrations[a] of selected metallic water quality parameters in the vicinity of the proposed coal handling facility of Thunder Bay Terminals Ltd., January, 1976 to October, 1976.

Parameters	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Site 7			Site 8			Site 9			Site 10		
	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s	$\bar{x}$	n	s
Total iron	.517	7	.137	.527	7	.194	.490	7	.241	.496	7	.556	.208	7	.125	.186	8	.101	.205	8	.123	.451	8	.199	.443	7	.192	.467	7	.167
Copper	.107	7	.253	< .017	7	.023	.012	7	.008	< .010	7	.008	.008	7	.005	< .007	8	.006	< .007	8	.004	< .009	8	.005	< .008	7	.004	.008	7	.004
Nickel	< .004	7	.001	< .033	7	.074	< .004	7	.001	< .005	7	.003	< .004	7	.001	< .005	8	.002	< .005	8	.002	< .004	8	.002	< .004	7	.002	< .004	7	.001
Zinc	.015	7	.008	.031	7	.030	.016	7	.005	< .037	7	.076	.016	7	.006	.009	8	.004	< .010	8	.006	< .013	8	.004	< .017	7	.020	.011	7	.006
Calcium	13.86	7	2.12	13.57	7	2.07	14.00	7	2.38	14.00	7	2.16	14.00	7	1.53	13.88	8	.641	13.38	8	1.85	13.88	8	2.75	14.00	7	2.45	13.83	6	.983
Magnesium	2.86	7	2.04	3.00	7	1.41	3.00	7	1.15	2.86	7	.690	2.71	7	.488	3.25	8	.707	2.88	8	.835	3.31	8	.704	2.86	7	1.07	3.50	6	2.26
Sodium	10.70	7	4.81	8.30	7	2.98	7.20	7	4.86	< 5.88	7	3.62	< 2.39	7	1.35	< 2.06	8	1.27	< 2.18	8	1.29	5.28	8	3.19	6.50	7	3.61	5.96	6	2.38
Potassium	1.25	7	.385	1.36	7	.871	1.06	7	.199	.957	7	.124	.971	7	.728	.781	8	.254	.788	8	.354	1.08	8	.318	.921	7	.104	.967	6	.125
Lead	< .013	7	.004	< .013	7	.004	< .010	7	.000	< .012	7	.002	< .011	7	.002	< .013	8	.005	< .012	8	.002	-	-	-	< .013	7	.005	< .022	7	.024
Cadmium	< .002	7	.000	< .002	7	.000	< .005	7	.007	< .002	7	.000	< .002	7	.000	< .002	8	.000	< .002	8	.000	< .002	8	.000	< .002	7	.000	< .002	7	.000

[a]All parameters reported in mg/l
n - Number of values
s - Standard deviation
$\bar{x}$ - Mean values